



Johnson Space Center Engineering Directorate L-8: Spacecraft Autonomy

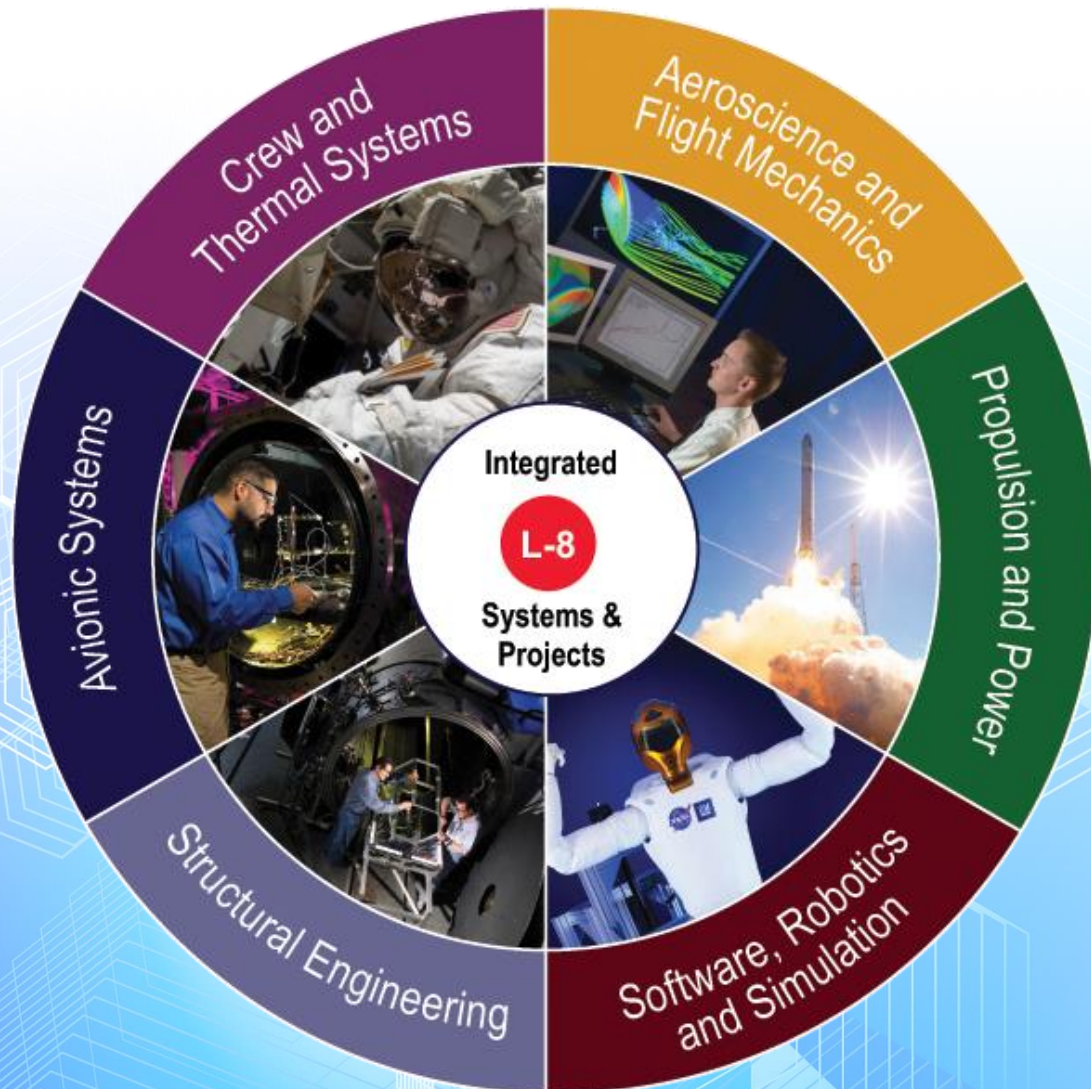
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JSC Engineering: HSF Exploration Systems Development

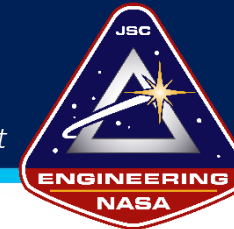


- We are sharpening our focus on Human Space Flight (HSF) Exploration Beyond Low Earth Orbit
- We want to ensure that HSF technologies are ready to take Humans to Mars in the 2030s.
 - Various Roadmaps define the needed technologies
 - We are attempting to define our activities and dependencies
- Our Goal: Get within 8 years of launching humans to Mars (L-8) by 2025
 - Develop and Mature the technologies and systems needed
 - Develop and Mature the personnel needed
- We need collaborators to make it happen, and we think they can benefit by working with us.

Boilerplate

EA Domain Implementation Plan Overview

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- Life Support
- Active Thermal Control
- EVA
- Habitation Systems

- Human System Interfaces
- Wireless & Communication Systems
- Command & Data Handling
- Radiation & EEE Parts

- Lightweight Habitable Spacecraft
- Entry, Descent, & Landing
- Autonomous Rendezvous & Docking
- Vehicle Environments



- Entry, Descent, & Landing
- Autonomous Rendezvous & Docking
- Deep Space GN&C

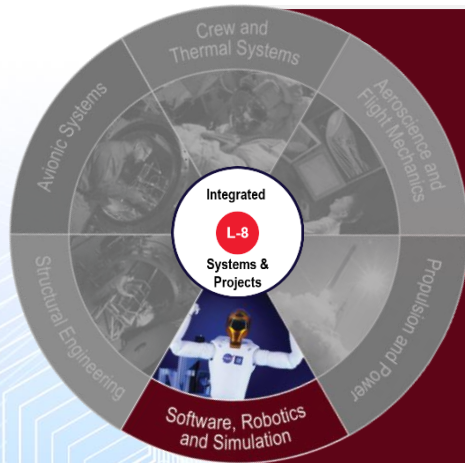
- Reliable Pyrotechnics
- Integrated Propulsion, Power, & ISRU
- Energy Storage & Distribution
- Breakthrough Power & Propulsion

- Crew Exercise
- Simulation
- Autonomy
- Software
- Robotics

Boilerplate

AA-2 | iPAS | HESTIA | Morpheus

Software, Robotics, & Simulation



- Crew Exercise
- Simulation
- **Autonomy**
- Software
- Robotics

Spacecraft Autonomy

- Spacecraft need to operate independently from ground control
- JSC is creating an architecture to define autonomous capabilities
- JSC provides a rich example and test facilities to prove out various autonomous systems technologies and interfaces
- Interested in partners wishing to advance technology in autonomy, human-system interaction

The Problem

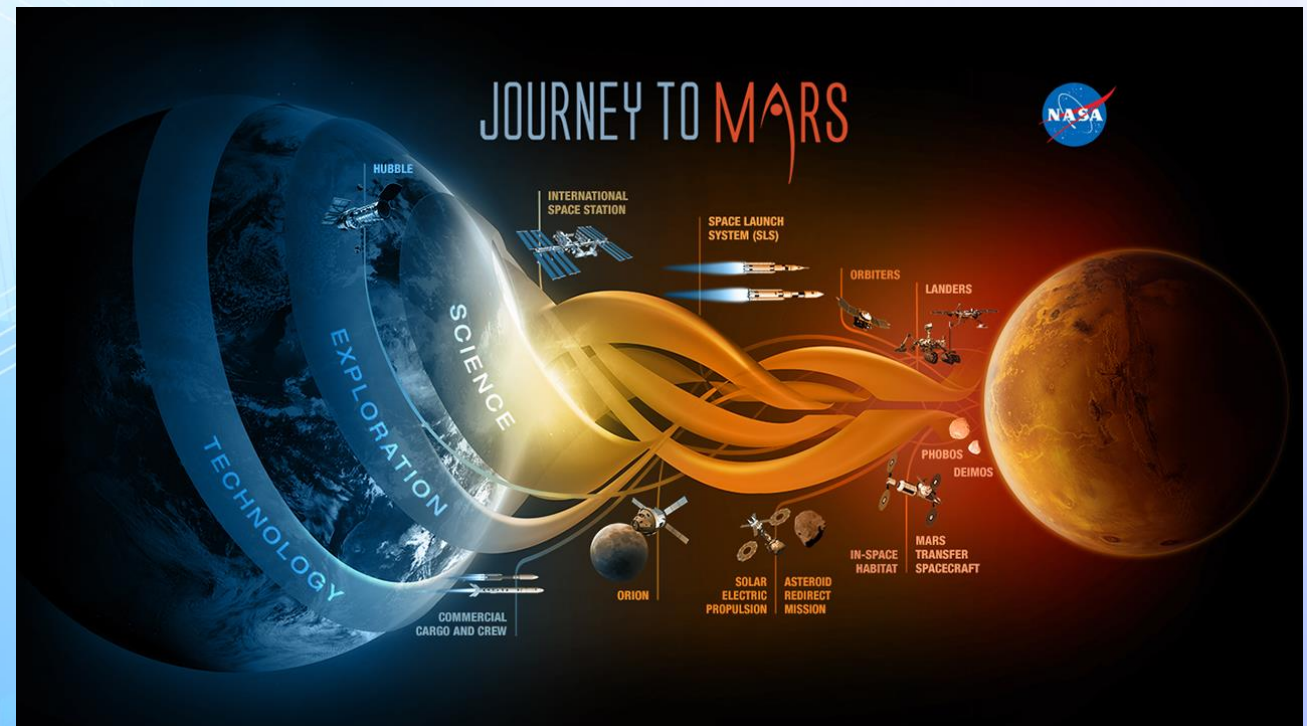
- Future exploration missions beyond low Earth orbit will require increasing independence from ground control
- Habitats and spacecraft may be left unattended (dormant) for significant periods
- NASA is interested in creating systems that can manage themselves and require less reliance on ground support to operate

Autonomy Drivers

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- Mission to Mars (500 day stay) requires autonomy for success
 - 40 minute round-trip time delays for any communication
 - Bandwidths on the order of kb/s
 - For surface operations, no/limited communications with Earth when Mars base is facing away from Earth (assuming limited satellite support around Mars)
 - No communications with Earth during the “superior conjunction”- 3 week period when Mars & Earth have the sun between them
- Mission scenarios have spacecraft sitting dormant in cislunar orbit for months to years before humans arrive
 - Autonomy must be able to handle both these uninhabited times as well as the crewed mission phases



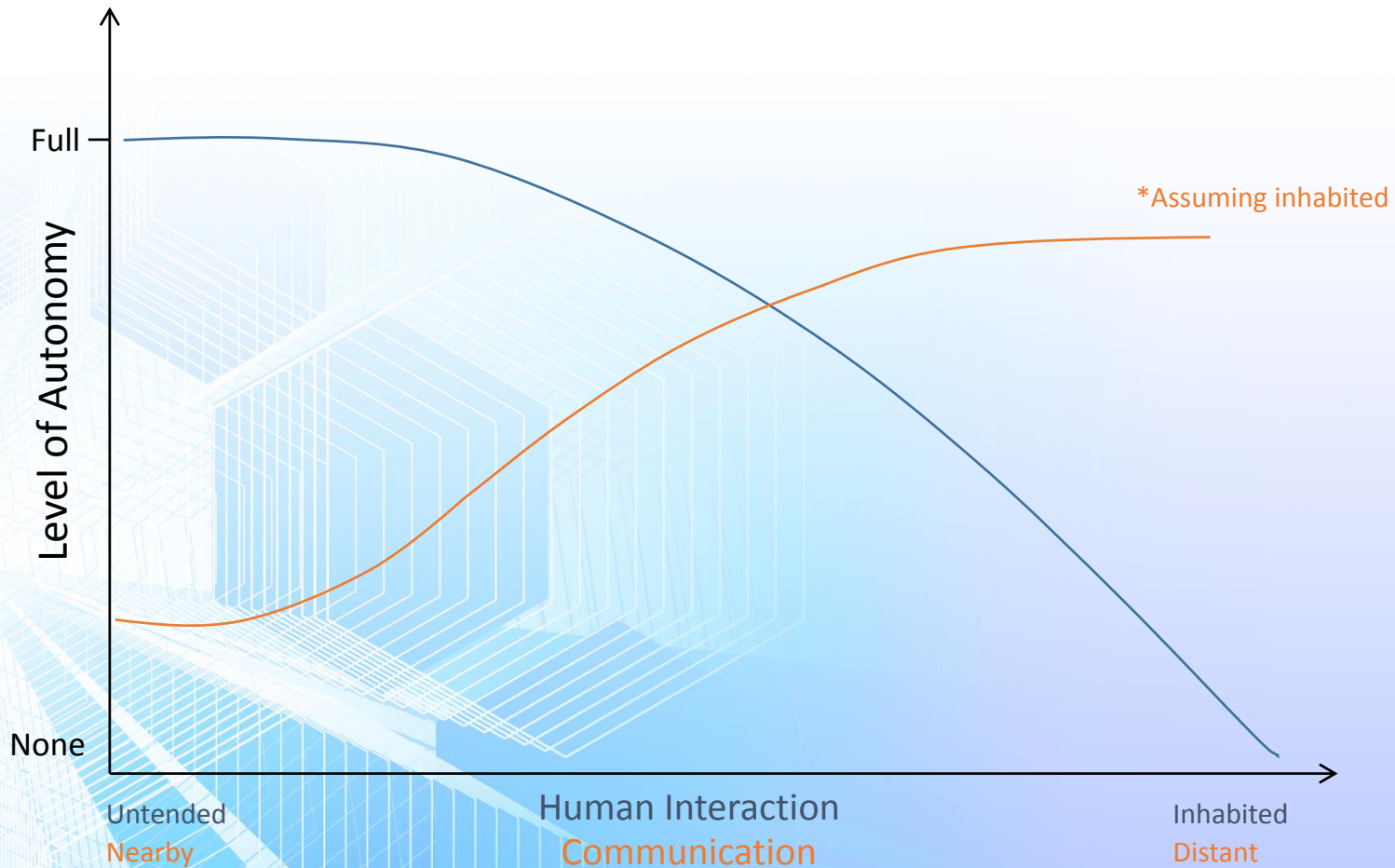
Connections to Industry

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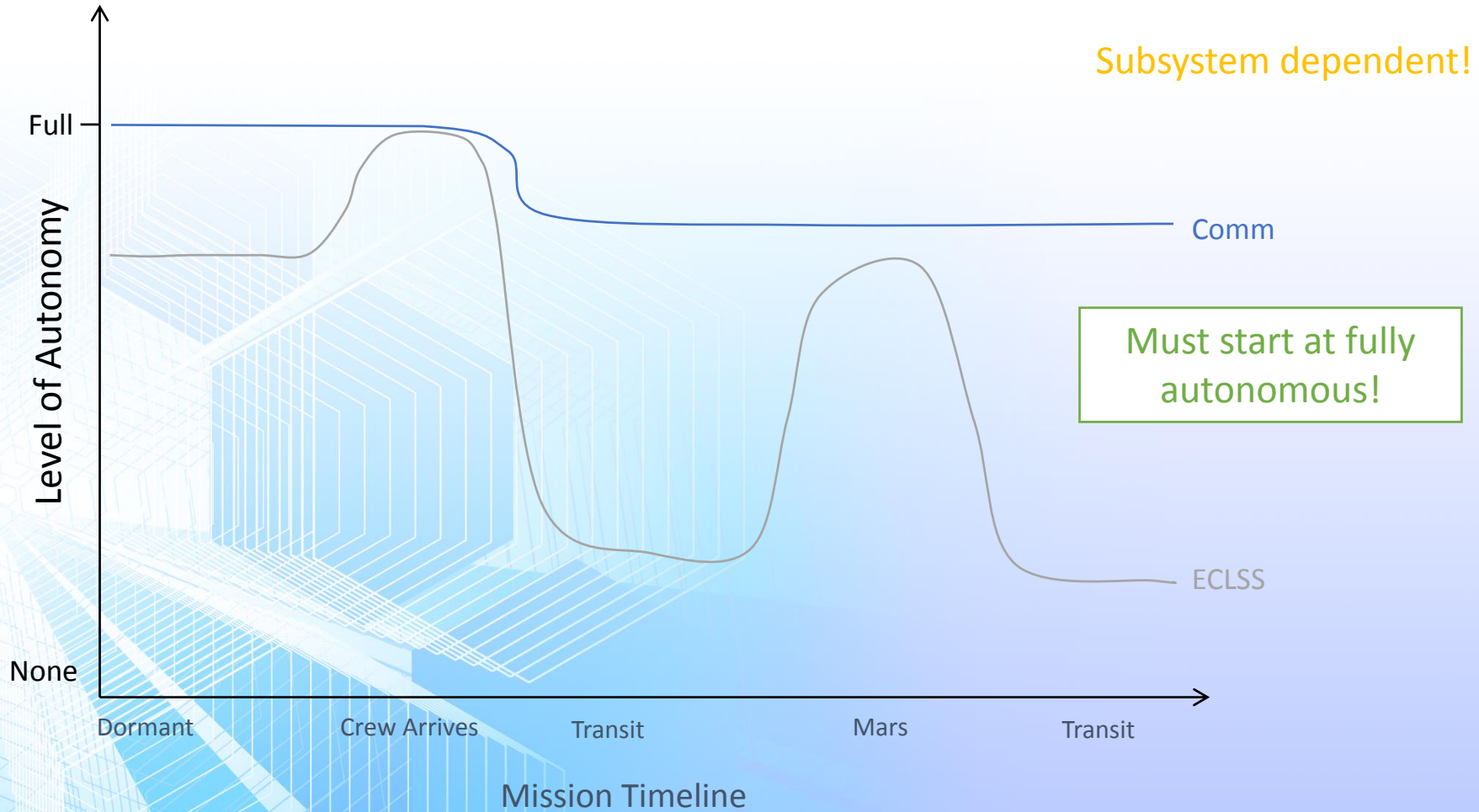
Variable Autonomy Approach

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Variable Autonomy Approach

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Spacecraft Autonomy Architecture Test Bed

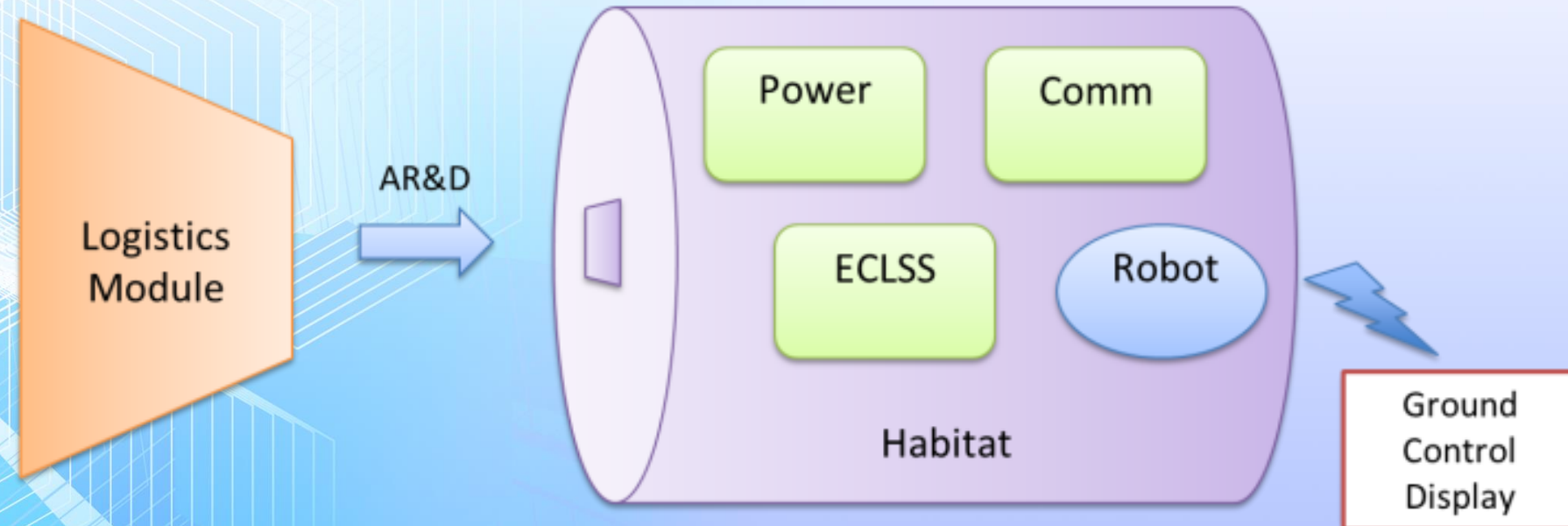
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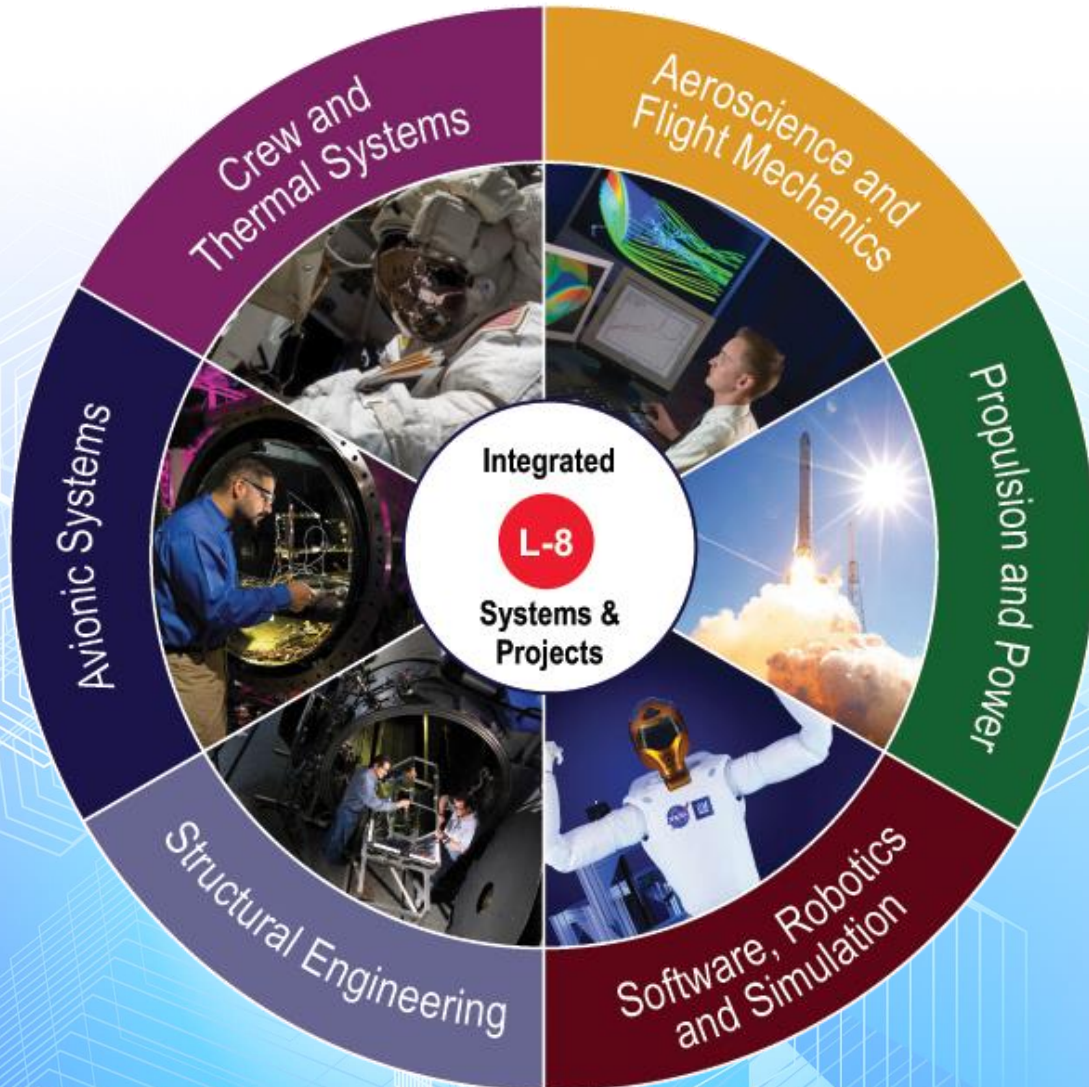
- Plan to create an architecture that has the following properties:
 - Can be used for all classes of autonomous systems
 - Standardizes information sharing and interfaces between technologies
 - Designed around formal verification and validation principles
- Focus on an “adjustable autonomy” approach

Resulting habitat test bed will provide countless opportunities to advance various technologies, including:

- Planning
- Modeling/Learning
- System/Environment State Awareness
- Command Interpretation
- User Interfaces



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 - Pointer to Co-Dev Announcements
 - Pointer to intake site

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